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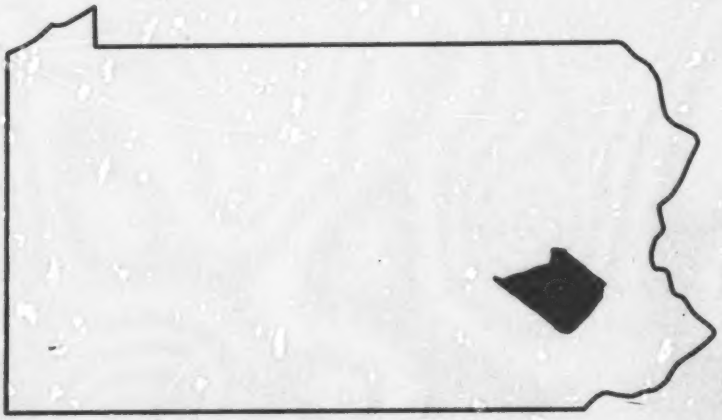
FLOOD INSURANCE STUDY

TOWNSHIP OF BETHEL, PENNSYLVANIA
BERKS COUNTY



JULY 15, 1988

COMPLETED

Federal Emergency Management Agency

COMMUNITY NUMBER - 421052

C.M.

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program (NFIP) have established repositories of flood hazard data for floodplain management and flood insurance study purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

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Exhibit 2 - Flood Insurance Rate Map Index and Street Index
Flood Insurance Rate Map

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FLOOD INSURANCE STUDY
TOWNSHIP OF BETHEL, BERKS COUNTY, PENNSYLVANIA

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the Township of Bethel, Berks County, Pennsylvania, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were prepared by the U. S. Geological Survey (USGS) for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. EMW-85-E-1823, Project Order No. 8. This work was completed in February 1987.

1.3 Coordination

On November 14, 1984, an initial Consultation and Coordination Officer's (CCO) meeting was held with representatives of FEMA, the township, and the USGS (the study contractor) to determine the streams to be studied by detailed methods.

On September 1, 1987, a final CCO meeting was held with representatives of FEMA, the township, and the study contractor to review the results of the study.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Township of Bethel, Berks County, Pennsylvania. The area of study is shown on the Vicinity Map (Figure 1).

The following streams were studied by detailed methods: Little Swatara Creek, from the downstream corporate limits to T-492; Crosskill Creek, from its confluence with Little Swatara Creek to a point approximately 0.7 mile upstream; Unnamed Tributary #1 to Little Swatara Creek, from its confluence with Little Swatara Creek to a point approximately 1,550 feet upstream of LR 06003; Unnamed Tributary #2 to Little Swatara Creek, from its confluence with Little Swatara Creek to a point approximately 0.5 mile upstream of State Route 501; and Mill Creek, from its confluence with Little Swatara Creek to Interstate Route 78. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction through February 1992.

Portions of Little Swatara Creek, Stone Creek, Mack Creek, Crosskill Creek, Mill Creek, and four unnamed tributaries were studied by approximate methods. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the Township of Bethel.

2.2 Community Description

The Township of Bethel is located in the western part of Berks County in southeastern Pennsylvania, approximately 20 miles northwest of Reading. It is bordered by the Township of Pine Grove to the northwest, the Township of Washington to the north, the Township of Wayne to the northeast, the Township of Upper Tulpehocken to the east, the Township of Tulpehocken to the south, and the Township of Bethel (Lebanon County) to the west.

2.3 Principal Flood Problems

Major floods cause localized inundation of structures along Little Swatara Creek and its principal tributaries.

2.4 Flood Protection Measures

There are no structural flood protection measures within the Township of Bethel that would alleviate flooding problems along streams within the community.

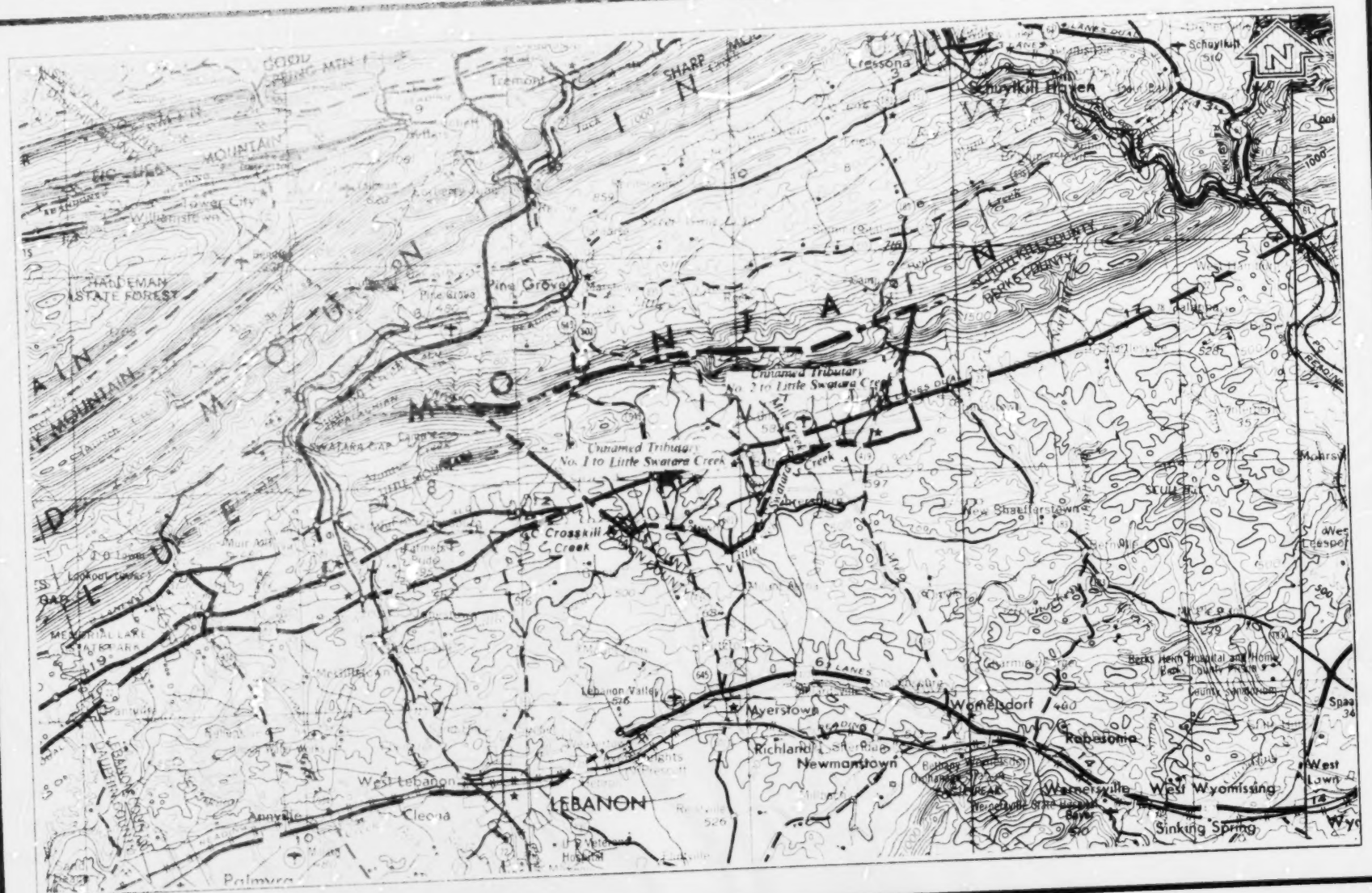


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWNSHIP OF BETHEL, PA

(BERKS CO.)

VICINITY MAP

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. A flood event of a magnitude which is expected to be equaled or exceeded once on the average during any 100-year period (recurrence interval) has been selected as having special significance for floodplain management and for flood insurance rates. This event, commonly termed the 100-year flood, has a 1 percent chance of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the community.

The flood-frequency discharge values for Little Swatara Creek were obtained from the regional flood-frequency report on Tropical Storm Agnes by the U. S. Army Corps of Engineers (COE) (Reference 1). This method is based on log-Pearson analyses of gage data and uses standard deviations, skews, and mean log coefficients that have been regionalized and placed on maps. The mean log coefficient map has been modified by the Susquehanna River Basin Commission.

The flood-frequency discharge values for the remaining streams studied by detailed methods were determined utilizing regional regression equations developed in USGS Water-Resources Investigations 82-21 (Reference 2).

A summary of the drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 1, "Summary of Discharges."

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGE (cfs) 100-YEAR
LITTLE SWATARA CREEK		
At lower corporate limits	57.9	13,700
At State Route 645	36.0	10,230
At TR 688	25.1	8,200
At LR 06007	18.1	6,700
At T-492	13.0	5,460
CROSSKILL CREEK		
At confluence with Little Swatara Creek	18.9	4,210
UNNAMED TRIBUTARY #1 TO LITTLE SWATARA CREEK		
At confluence with Little Swatara Creek	1.96	810
UNNAMED TRIBUTARY #2 TO LITTLE SWATARA CREEK		
At confluence with Little Swatara Creek	2.01	830
MILL CREEK		
At confluence with Little Swatara Creek	3.06	1,120

Cross sections for the streams studied by detailed methods were field surveyed and located at close intervals above and below bridges and culverts in order to compute the significant backwater effects of these structures. All bridges, dams, and culverts in the community were field surveyed to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1) and the Flood Insurance Rate Map (Exhibit 2) where applicable.

Water-surface elevations of floods of the selected recurrence intervals for Little Swatara Creek from the downstream corporate limits to State Route 645 were computed using the USGS WSPRO step-backwater computer program (References 3 and 4).

For the remaining portion of Little Swatara Creek and the other streams studied by detailed methods, normal depths of flooding for the 100-year recurrence interval were estimated from the regional

relationship between drainage area and flood depth prepared by the USGS (Reference 5). This relationship was developed by means of regional regression analyses of basin areas and 100-year within-channel depths observed at stream gages. Depths were adjusted on the basis of hydraulic calculations to account for increased depth due to backwater from hydraulic structures such as bridges and culverts (References 6, 7, and 8). Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

Channel roughness factors (Manning's "n") used in the hydraulic computations were assigned on the basis of engineering judgment and field inspection of the floodplain areas. The channel "n" values for the streams studied by detailed methods ranged from 0.026 to 0.033, and the overbank "n" values ranged from 0.050 to 0.055.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps; the descriptions of the marks are presented in Elevation Reference Marks (Exhibit 3).

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study provides 100-year flood elevations and delineations of the 100-year floodplain boundaries to assist communities in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. For the streams studied in detail, the 100-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:24,000 with a contour interval of 20 feet (Reference 9).

For the streams studied by approximate methods, the 100-year flood boundaries were delineated using the Flood Hazard Boundary Map for the Township of Bethel (Reference 10).

The 100-year floodplain boundaries are shown on the Flood Insurance Rate Map (Exhibit 2). On this map, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE). Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced.

The area between the floodway and 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2 .

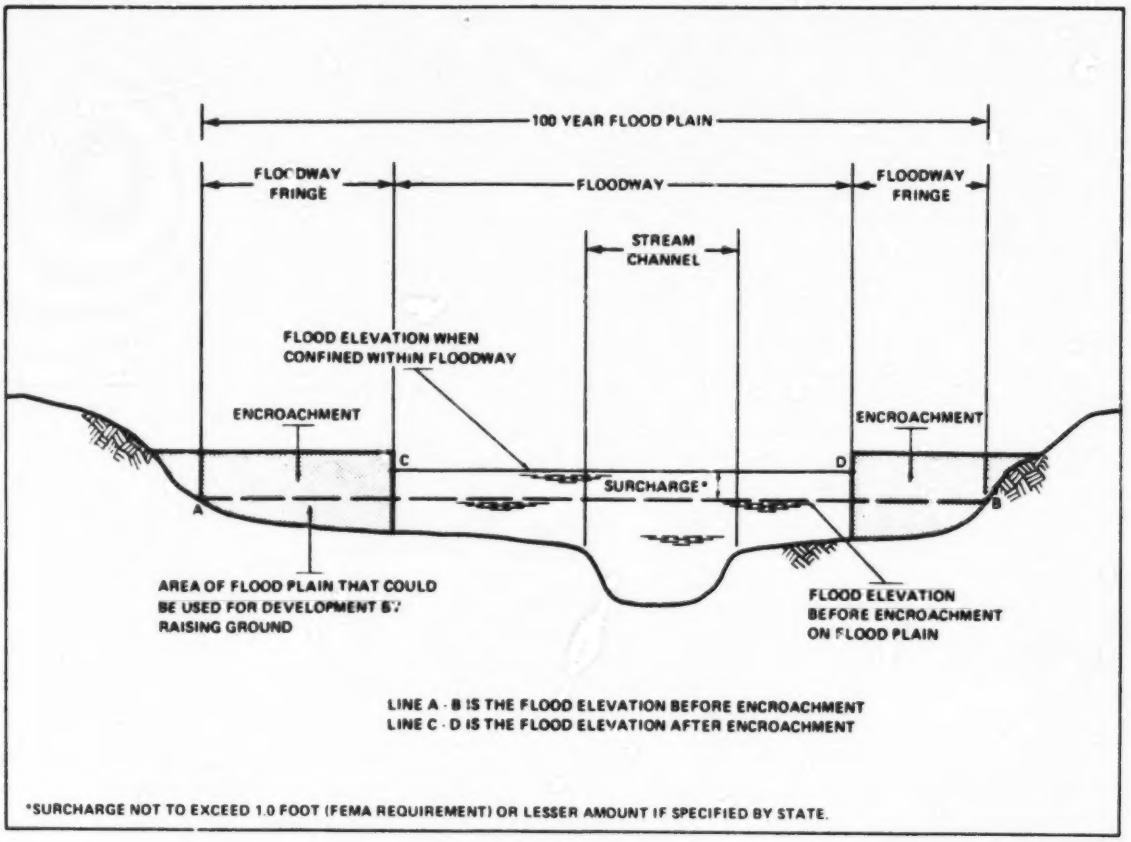
No floodways were calculated as part of this study.

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A - B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C - D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FLOODWAY SCHEMATIC Figure 2

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-depths derived from the detailed hydraulic analyses are shown within this zone.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 100-year floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or depths are shown within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain,and to areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 100-year floodplain. The locations of selected cross sections used in the hydraulic analyses are shown where applicable.

7.0 OTHER STUDIES

Flood Insurance Studies for the Townships of Bethel (Lebanon County) and Upper Tulpehocken have been published (References 11 and 12). The results of this study are in agreement with the results of those studies.

A Flood Insurance Study for the Township of Tulpehocken is currently being prepared (Reference 13). The results of that study will be in agreement with the results of this study.

Due to its more detailed nature, this study supersedes the Flood Hazard Boundary Map for the Township of Bethel (Reference 10).

8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, the Natural and Technological Hazards Division, Liberty Square Building (Second Floor), 105 South Seventh Street, Philadelphia, Pennsylvania 19106.

9.0 BIBLIOGRAPHY AND REFERENCES

1. U. S. Army Corps of Engineers, New York District, Hydrologic Study, Tropical Storm Agnes, New York, New York, December 1975.

2. U. S. Department of the Interior, Geological Survey, Water-Resources Investigations 82-21, Evaluation of the Streamflow-Data Program in Pennsylvania by H. N. Flippo, Jr., Harrisonburg, Pennsylvania, 1982.

3. U. S. Federal Highway Administration, Report FHWA/RD-86/108, Bridge Waterways Analysis Model/Research Report by J. O. Shearman, W. H. Kirby, V. R. Schneider, and H. N. Flippo, Jr., Washington, D. C., 1986.

4. National Technical Information Service, Bridge Waterways Analysis Model/User's Instructions by J. O. Shearman, W. H. Kirby, and V. R. Schneider, Springfield, Virginia, 1985.

5. U. S. Department of the Interior, Geological Survey, Water Resources Investigations 86-4195, Technique for Estimating Depths of 100-Year Floods in Pennsylvania by H. N. Flippo, Jr., Harrisburg, Pennsylvania, 1986.

6. U. S. Department of the Interior, Geological Survey, Techniques of Water Resources Investigations, Measurement of Peak Discharge at Culverts by Indirect Methods by G. L. Bodhaine, Washington, D. C., 1968.

7. U. S. Department of the Interior, Geological Survey, Techniques of Water Resources Investigations, Measurement of Peak Discharge at Width Contractions by Indirect Methods by H. F. Matthai, Washington, D. C., 1967.

8. U. S. Department of the Interior, Geological Survey, Techniques of Water Resources Investigations, Measurement of Peak Discharge at Dams by Indirect Methods by Harry Hulsing, Washington, D. C., 1976.

9. U. S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 20 Feet: Bethel, Pennsylvania, 1955, Photorevised 1974; Strausstown, Pennsylvania, 1955, Photorevised 1974.

10. Federal Emergency Management Agency, Federal Insurance Administration, Flood Hazard Boundary Map, Township of Bethel, Berks County, Pennsylvania, May 28, 1976.

11. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, Township of Bethel, Lebanon County, Pennsylvania, Washington, D. C., September 30, 1981.

12. Federal Emergency Management Agency, Flood Insurance Study, Township of Upper Tulpehocken, Berks County, Pennsylvania, Washington, D. C., July 16, 1982.

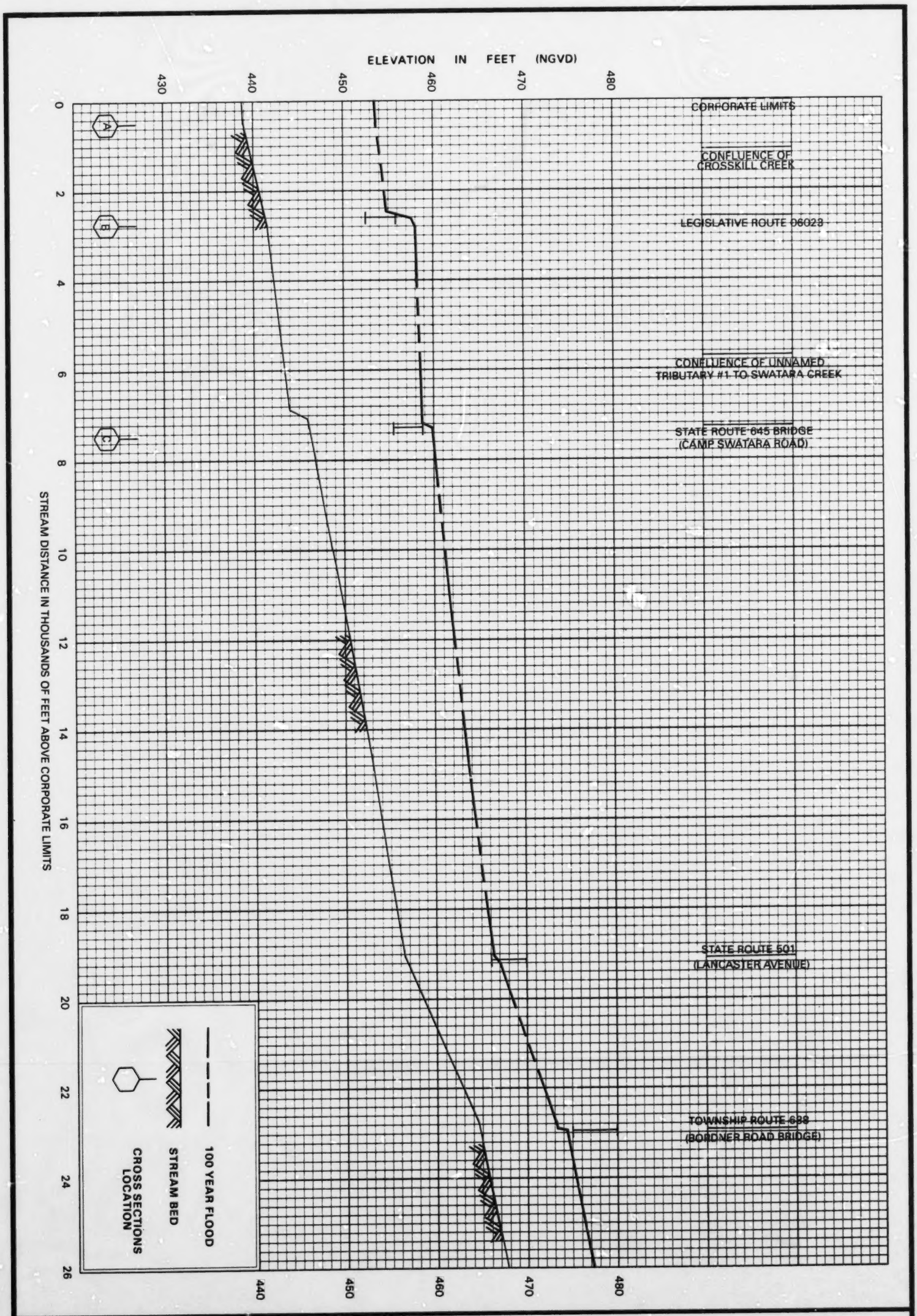
13. Federal Emergency Management Agency, Flood Insurance Study, Township of Tulpehocken, Berks County, Pennsylvania (Unpublished).

EXHIBIT 3 - ELEVATION REFERENCE MARKS

Reference Mark	FIRM Panel	Elevation (Feet NGVD)	Description of Location
RM 1	15	455.41	PDH disk set in southwest corner of LR 06003 bridge over Crosskill Creek at Crosskill Mills.
RM 2	15	464.23	PDH disk set in southwest wing wall of LR 06003 bridge over Unnamed Tributary # 1 to Little Swatara Creek, approximately 300 feet east of State Route 645.
RM 3	15	455.92	PDH disk set in southeast wing wall of LR 06023 bridge over Little Swatara Creek, approximately 1,300 feet south of Frystown Road (LR 06003).
RM 4	15	460.19	PDH disk on southwest wing wall of State Route 645 (Swatara Camp Road) bridge over Little Swatara Creek, approximately 2,500 feet south of Frystown.
RM 5	15	462.45	Railroad spike in 2-bole, 12-inch cherry tree, approximately 200 feet east of Little Swatara Creek,100 feet south of high-voltage power lines, and approximately 3,000 feet west (along same power lines) of State Route 501, at corner of cultivated field.
RM 6	15	472.59	PDH disk set in southeast corner of State Route 501 bridge over Little Swatara Creek.
RM 7	15	478.61	Chiseled square cut on northeast corner of north abutment of T-688 bridge over Little Swatara Creek.
RM 8	15	483.38	Chiseled square cut on top of west end of 30-inch reinforced concrete pipe under T-688, approximately 2,500 feet south of Lancaster Road (State Route 501).
RM 9	20	485.51	PDH disk set in top of northeast wing wall of Legislative Route 06007 bridge over Little Swatara Creek.

EXHIBIT 3 - ELEVATION REFERENCE MARKS - continued

Reference Mark	FIRM Panel	Elevation (Feet NGVD)	Description of Location
RM 10	20	506.14	Yellow paint mark on northeast corner of 2.5- x 6.5-foot concrete pad at south doorway to milking parlor on east side of barn, approximately 1,800 feet west along access road from intersection of T-674 and Little Swatara Church Road.
RM 11	20	504.00	Chiseled square cut on northwest wing wall of T-674 bridge over Little Swatara Creek, approximately 1,900 feet south of Old U. S. Route 22.
RM 12	20	509.50	Chiseled square cut on northwest corner of northeast wing wall of T-492 bridge over Little Swatara Creek, approximately 1,500 feet south of Old U. S. Route 22.
RM 13	20	532.57	Chiseled square cut on top of southeast corner of south headwall of arched culvert on Interstate Route 78 over Mill Creek, approximately 2,200 feet west of T-674.
RM 14	20	515.10	PDH disk set in southwest wing wall of Old U. S. Route 22 bridge over Mill Creek, approximately 1,600 feet west of T-674.



FEDERAL EMERGENCY MANAGEMENT AGENCY

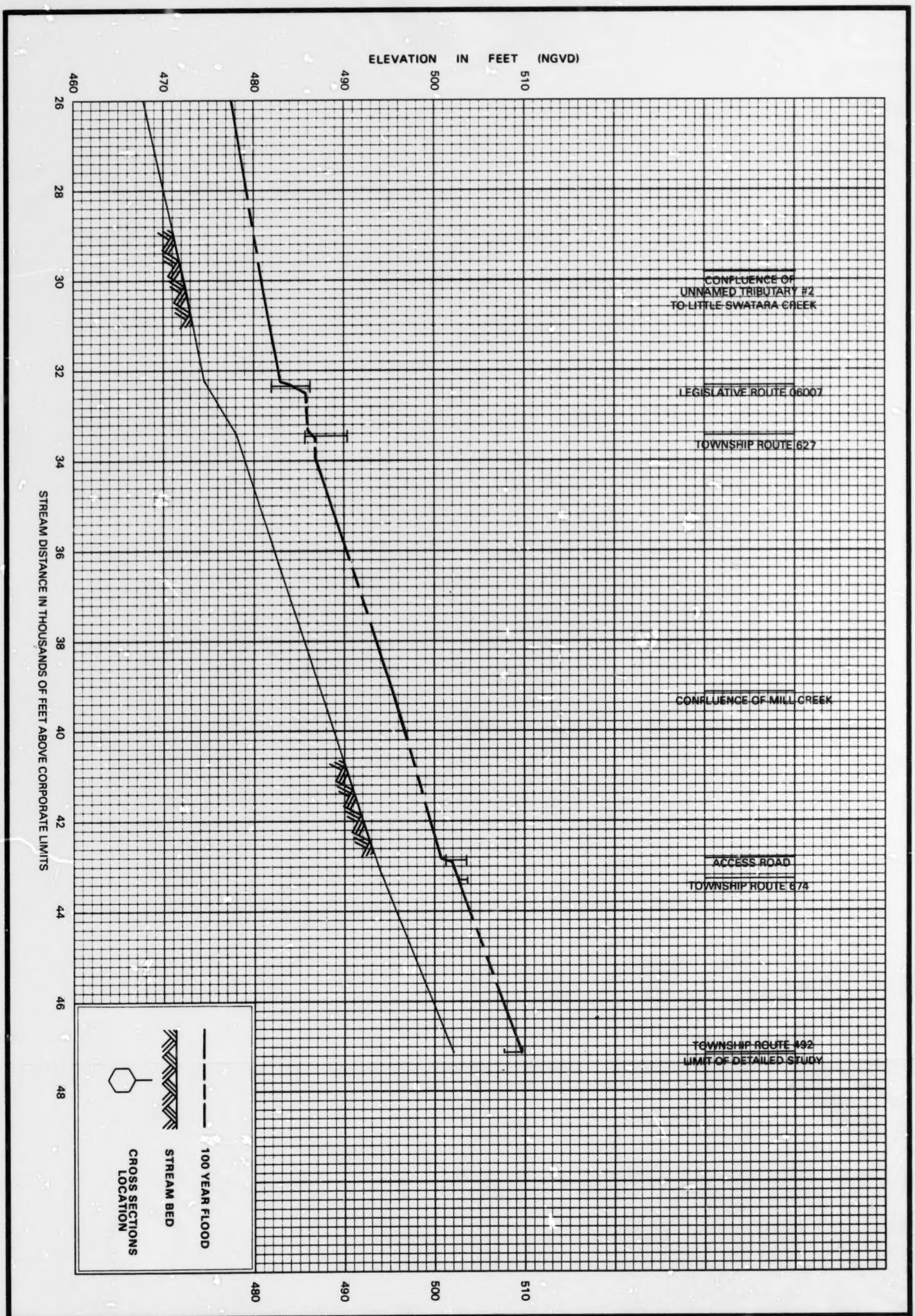
TOWNSHIP OF BETHEL, PA

(BERKS CO.)

FLOOD PROFILES

LITTLE SWATARA CREEK

01P



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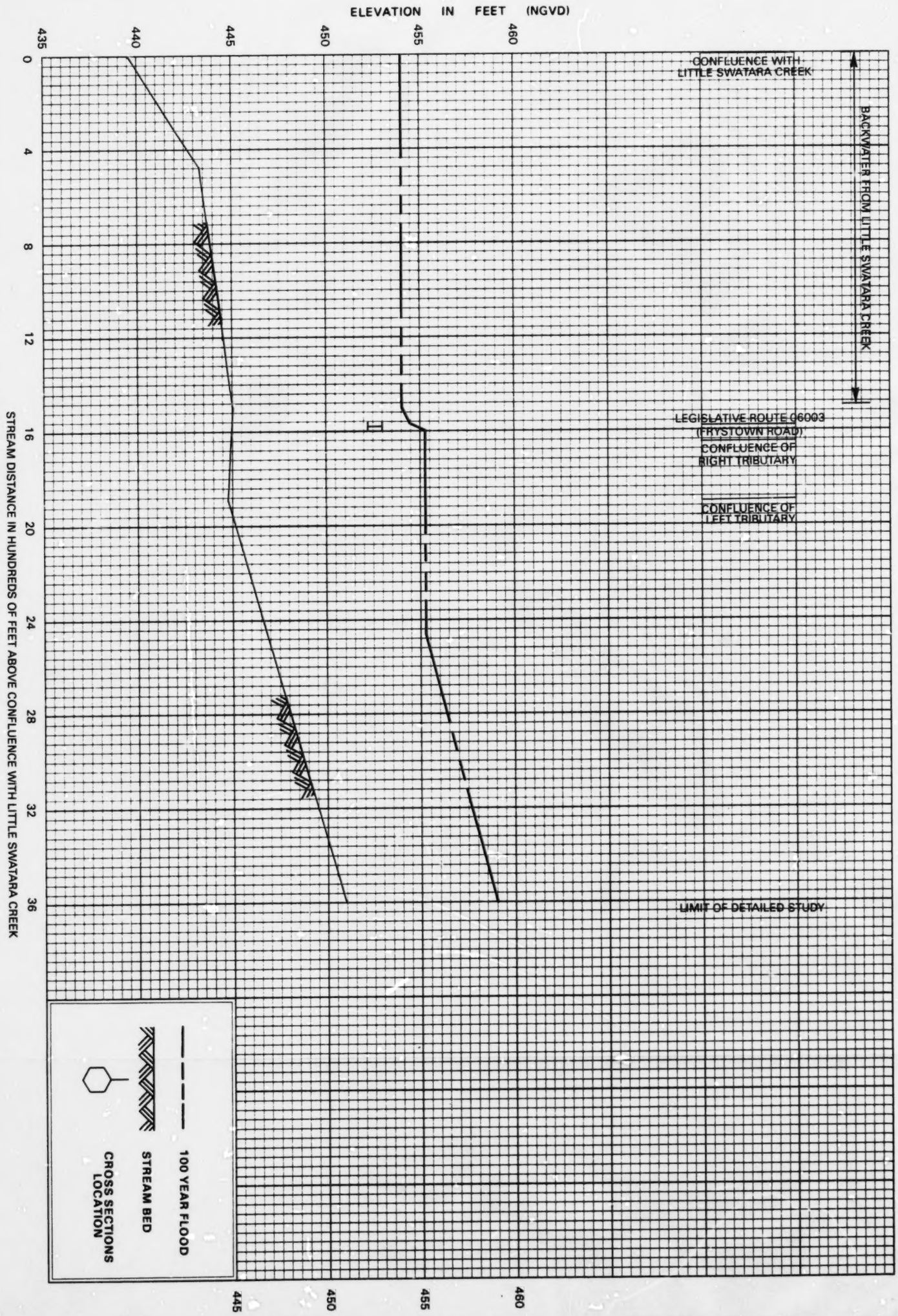
FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWNSHIP OF BETHEL, PA

(BERKS CO.)

FLOOD PROFILES

LITTLE SWATARA CREEK



FEDERAL EMERGENCY MANAGEMENT AGENCY

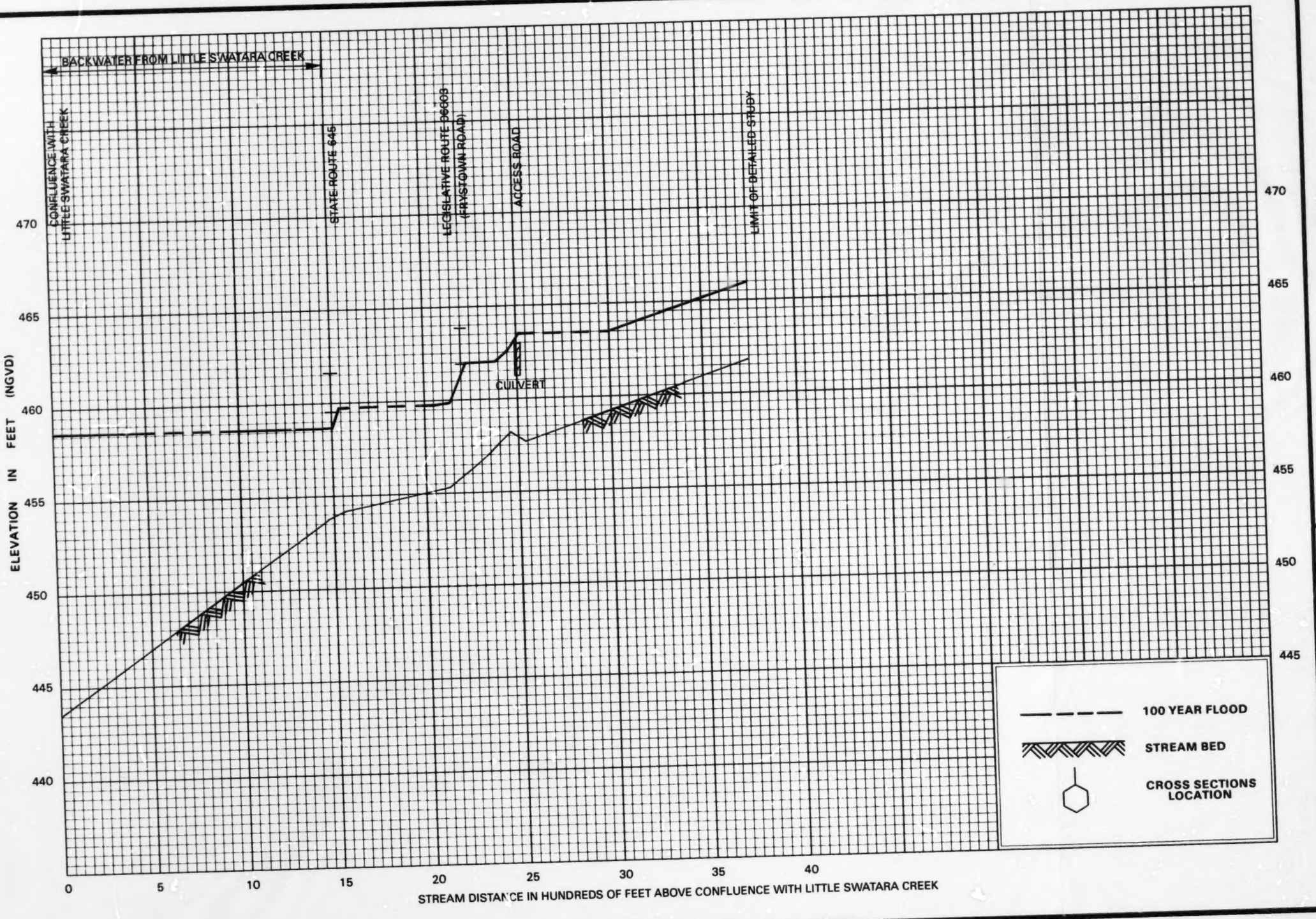
TOWNSHIP OF BETHEL, PA

(BERKS CO.)

03P

FLOOD PROFILES

CROSSKILL CREEK



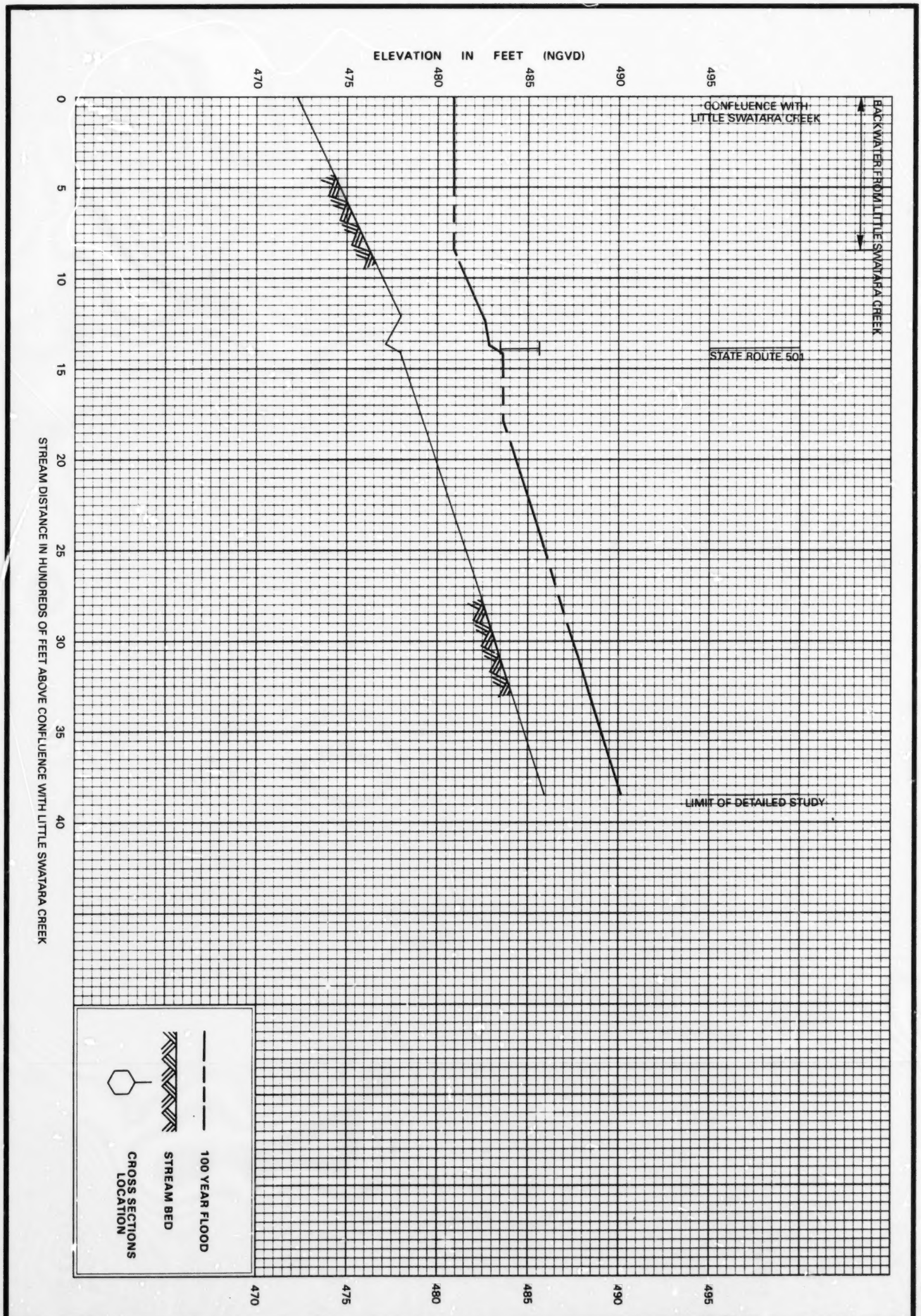
FLOOD PROFILES

UNNAMED TRIBUTARY #1 TO LITTLE SWATARA CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWNSHIP OF BETHEL, PA
(BERKS CO.)

04P



05P

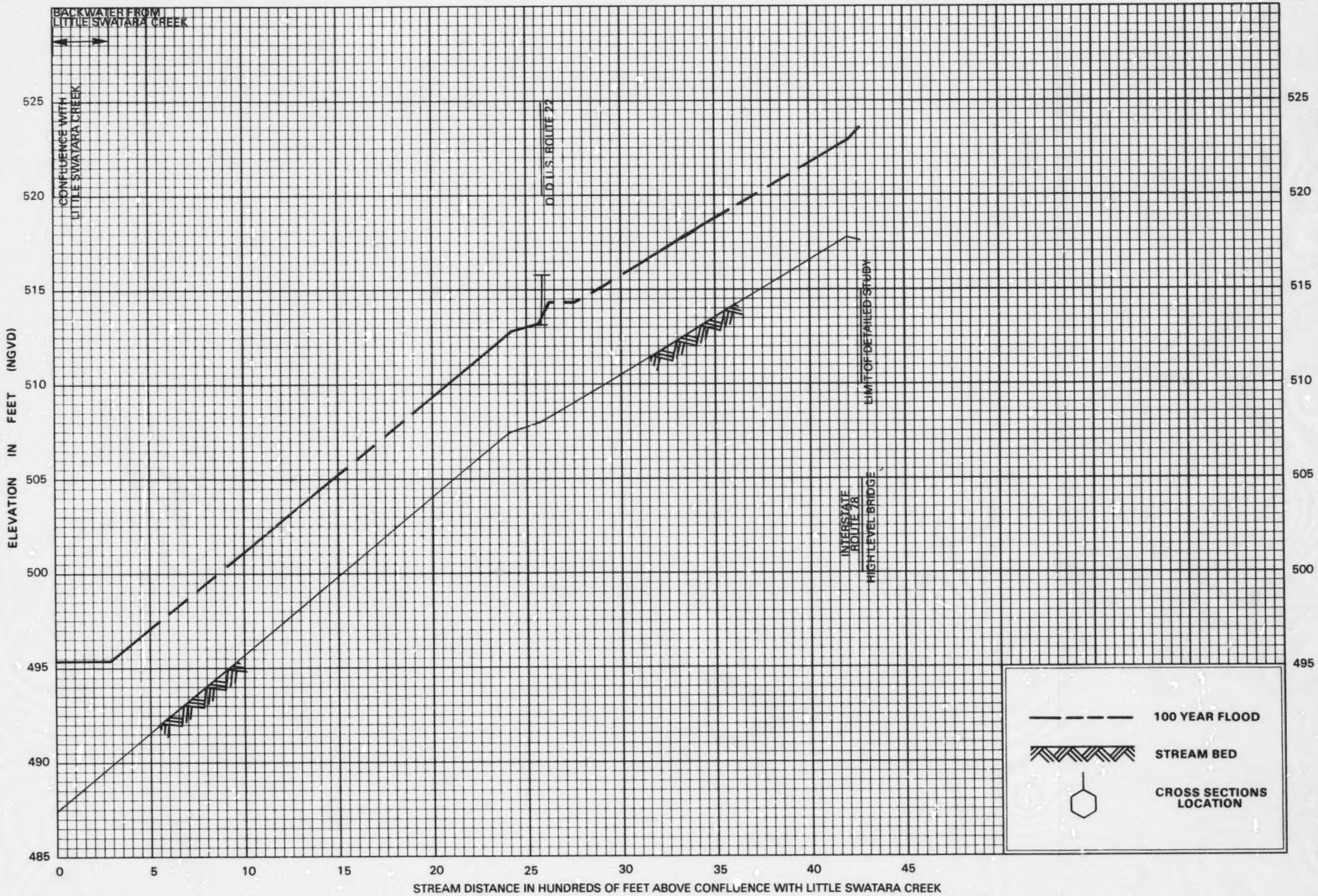
FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWNSHIP OF BETHEL, PA

(BERKS CO.)

FLOOD PROFILES

UNNAMED TRIBUTARY #2 TO LITTLE SWATARA CREEK



FLOOD PROFILES

MILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWNSHIP OF BETHEL, PA
(BERKS CO.)

06P